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Im Auftrag

For the President of the European Patent Office

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Scrolling colour projection system with lamp synchronisation

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Scrolling colour projection system with lamp synchronisation

The present invention relates to a scrolling colour projection system comprising a pulsed lamp and a colour scanner for generating a light beam with a plurality of scrolling colour fields, arranged to illuminate a display device to produce a projection of an image generated by the display device. The invention also relates to a method for driving such a system.

Such projection systems are particular in that light from a light source is divided into a plurality of beams, which are sequentially scrolled over a display device, e.g., a reflective LCD, and then projected by means of a lens. Normally, the three beams (R, G, B) are arranged to form three horizontal bars with a total height large enough to cover the reflective display. The bars are scrolled, e.g., from top to bottom, and are synchronized with the display so that they complete a scrolling sequence within one picture frame.

In such projector systems, it is advantageous to use a light source, e.g., a UHP (ultra high performance) lamp from Philips, having a superposed current pulse to stabilize the arc position. In a scrolling colour type of projection system, such a current pulse may interfere with the colour scanner and result in visible interference patterns in the projected image. In principle, the pulse acts as a stroboscope, highlighting a momentary image of the scanner, and may make interference patterns in the form of colour bars or the intermediate fields (spokes) visible on the screen. If the pulse frequency is a sub-frequency of the frame rate, the interference pattern will be fixed, and if the lamp frequency is out of phase with the frame rate, the bars will roll across the screen.

An object of the present invention is to mitigate the above problem, and reduce image interference in a scrolling projector system.

This and other objects are achieved with a projector and a method of the type mentioned by way of introduction, wherein the lamp frequency is controlled so as to be related to the frame rate of the display device.

According to the invention, the above mentioned interference patterns are reduced or eliminated by controlling the lamp frequency depending on the frame rate. Extra optical components, which cause light loss, are not necessary.

By controlling the lamp frequency in relation to the frame rate, a generated interference pattern can be controlled to be distributed over several frame periods and over the entire height of the display. In particular, the pattern can be controlled in such a way that it is not perceivable by the human eye.

According to a preferred embodiment, the lamp frequency is controlled so that the resulting lamp pulse frequency is an average of two consecutive scanner sub-harmonic frequencies causing visible interference patterns in the image. The lamp pulse frequency is the frequency of the lamp stabilisation pulses of the light flux, typically, but not necessarily, twice the lamp frequency. A scanner sub-harmonic frequency is a frequency which is a sub-harmonic of either the frame rate itself, or the rate of intermediate fields between colour bars (spokes), which is three times the frame rate in a three colour system, e.g., R, G, B.

By such a selection of the lamp frequency, the resulting interface pattern is average over time and space, making it unperceivable to the human eye.

The lamp frequency can be controlled by obtaining a frame synchronization pulse signal from the display driver, multiplying this synchronization signal by a factor to obtain a lamp frequency control signal, and controlling the lamp frequency in accordance with this control signal. This provides for a simple implementation of the invention, requiring only a frequency multiplier and a lamp driver of which the lamp frequency can be controlled.

The multiplier factor is preferably defined as

$$k = (3/4)*(1/n + 1/m),$$

where n is the number of a first scanner sub-harmonic frequency, and m is the number of a second scanner sub-harmonic frequency (n and m are not necessarily integers).

Such a factor results in a lamp pulse frequency which is an average of two scanner sub-harmonic frequencies, as defined above. Note that the relationship is based upon the fact that the frequency of the pulse is twice that of the lamp, and that there are three separate fields in the scanning beam.

The numbers n and m can preferably be chosen as numbers of consecutive sub-harmonics causing visible interference patterns in the image.

This and other aspects of the invention will be apparent from the preferred embodiments more clearly described with reference to the appended drawings.

Fig 1 is a schematic view of a scrolling colour projection system according to prior art.

Fig 2 shows a scanner output of the projection system in fig 1.

Fig 3 is a diagram of a current waveform for a UHP lamp with pulsed arc stabilisation.

Fig 4 is a diagram of a lamp flux output corresponding to the current in fig 3.

Fig 5 is a schematic view of a scrolling colour projection system according to an embodiment of the invention.

Fig 6 shows scanner positions corresponding to pulses in light flux.

Fig 7 shows the three colours in fig 6, each represented separately.

A projection system with scrolling colour scanning according to prior art, also referred to as a Scrolling Colour Sequential (SCS) system, is illustrated in fig 1. The system comprises an display driver 1, arranged to receive a data or video input stream 2, from e.g. a personal computer or a video cassette recorder (not shown), and to drive a display device 3, such as a reflective LCD. A light source 4, preferably a UHP lamp followed by an integrator, is controlled by a lamp driver 12 to generate a light beam 5a, which passes through a colour scanner (6, 8a, 8b, 8c, 9). The colour scanner converts the light beam 5a from the lamp 4 into a beam 5b having a plurality of differently coloured fields, typically three colour bars (R, G, B), continuously scrolling from top to bottom (see fig 2).

In the example illustrated in fig 1, a first set of mirrors 6 divide the beam 5a into three beams 7a, 7b, 7c. These beams are guided through three scanning prisms 8a, 8b, 8c (red, green and blue), and a second set of mirrors 9 recombine the beams into one beam 5b, as described above. The mirrors 6, 9 and the prisms 8a, 8b, 8c together form the colour scanner.

The beam 5b with scrolling colour bars 23 is directed onto the display device 3, and an image generated by the display device 3 is reflected back into a polarizing beam splitter (PBS) 10. The PBS 10 directs the reflected image to a projection lens 11, for projection onto a suitable screen (not shown).

The scanning performed by the colour scanner 8a, 8b, 8c is synchronized with the frame rate of the video data 2, so that the colour bars 23 of the beam 5b complete a

scrolling sequence (return to original position) in one frame period T_F. This is illustrated in fig 2.

The diagram in fig 3 shows a typical current waveform 20 with period T_L in the UHP lamp 4, including a pulse 21 to stabilise the arc position. The diagram in fig 4 shows the corresponding lamp flux 22 from the projection lamp 4, which is essentially the rectified waveform 20 in fig 3. As is clear from fig 4, the lamp flux 22 comprises a DC flux with a superimposed AC light flux, resulting from the stabilizing pulse 21. As a consequence from the rectification, the period T_{AC} of the AC component is only half of T_L, i.e. the pulse frequency is twice the lamp frequency.

As mentioned above, the AC light flux resulting from the stabilization pulse acts as a fictive light source, and causes a stroboscopic effect on the colour scanner 8a, 8b, 8c. When the frequency of this AC component of the light flux (referred to as the pulse frequency) is a sub-harmonic of the display frame rate frequency, the colour bars 23 can be 'captured' by the stroboscopic effect, resulting in visible colour bars in the projected image. When lamp frequency and frame rate frequency are locked, the visible bars are fixed in one position. If they are not locked (i.e. a-synchronic), the visible bars will be scrolling over the screen because lamp and scanner are a-synchronic. The phase between lamp frequency and frame rate frequency determines the position of the colour bars on the screen.

Because there is, in practice, an overlap or a distance 24 between adjacent colour bars of the scanner, additional interference patterns may be visible. These 'spokes' 24 of the scanner will be visible when the pulse frequency is a sub-harmonic of these 'spokes'. As the spoke frequency is three times the frame rate (in the illustrated case with three colours), this will occur even more often.

The following table includes a number of sub-harmonics that can be distinguished in case the colour bars are equal in width. Of course, there are in principle an infinite number of sub-harmonics, but the table only includes those that result in the most visible interference patterns. Display frame rate frequency is assumed to be 180 Hz (i.e. spoke frequency is 540 Hz), and scanning is performed with linear scan velocity:

Table 1 Scanner sub-harmonics.

Lamp frequency	Lamp pulse frequency	Sub-harmonic of frame rate freq.	Sub-harmonic of spoke frequency
270,0	540,0		1
180,0	360,0		1,5
135,0	270,0		2
90,0	180,0	1	3
67,5	135,0		4
60,0	120,0		4,5
54,0	108,0		5
45,0	90,0	2	6
38,6	77,1		7
36,0	72,0		7,5
33,8	67,5		8
30,0	60,0	3	9
27,0	54,0		10
25,7	51,4		10,5
24,5	49,1		11
22,5	45,0	4	12
20,8	41,5		13
20,0	40,0		13,5
19,3	38,6		14
18,0	36,0	5	15

For the lamp frequencies causing a pulse frequency which is a sub-harmonic of the frame rate, fixed colour bars will be visible on the screen. For spoke frequency sub-harmonics, spokes will be visible on the screen. All these frequencies are here referred to as scanner sub-harmonic frequencies.

As mentioned above, table 1 includes the lamp frequencies resulting in the most visible interference patterns. With different frame rate, number of spokes, distance between spokes, etc, these lamp frequencies can be different. Such a selection of lamp frequencies, resulting in noticeable interference patterns, can be utilized when optimising a synchronization according to the invention. This will be described below, with reference to table 1 as an example of such a selection.

According to the present invention, such interference pattern can be mitigated or alleviated by correlating the lamp frequency with the frame rate. This can be accomplished by introducing a synchronizer 13 between the lamp driver 12 and the display driver 1, as is illustrated in fig 5. The synchronizer 13 is adapted to receive a synchronisation pulse signal 15 from the display driver 1, and generate a lamp frequency control signal 14 by multiplying this signal 15 by a factor k. The lamp driver 12 is adapted to receive this control signal 14, and to control the lamp frequency f_{lamp} in accordance with this control signal 14. As a

consequence, the lamp frequency is controlled depending on the frame rate, and also synchronised with the frame rate.

In the following description, the lamp frequency f_{lamp} is controlled to be a fixed ratio of the frame rate f_{frame}, but this is not a limitation of the present invention, as more complex, dynamic or adaptive, relationships are envisageable.

The factor k can preferably be an average of two consecutive sub-harmonic frequencies, from the first column in table 1. For a linear scan velocity, this can be expressed as:

$$f_{lamp} = (1/2)*(f_n + f_m), \qquad (1)$$

where f_n equals a first scanner sub-harmonic lamp frequency and f_m the next consecutive scanner sub-harmonic lamp frequency according to a selection such as table 1. It is clear from above that in the present example, a particular lamp frequency f_{lamp} causes a sub-harmonic interference pattern if

$$f_{pulse} = 2*f_{lamp} = (1/n)*f_{spoke} = (1/n)*3*f_{frame},$$

where f_{pulse} is the frequency of the stabilisation pulse of the lamp, f_{spoke} is the frequency of the spokes between the scrolling colour bars, and n is the number of the sub-harmonic (note that n is not necessarily an integer, as is clear from table 1).

This leads to the following expression for f_n:

$$f_n = (3/2)*(1/n)*f_{frame}. \qquad (2)$$

By substituting equation 2 into equation 1, a relationship can now be defined between the desired lamp frequency and the frame rate frequency:

$$f_{lamp} = f_{frame}*(3/4)*(1/n + 1/m), \qquad (3)$$

where n is the number of a first scanner sub-harmonic lamp frequency, and m is the number of the next consecutive scanner sub-harmonic lamp frequency in a selection such as table 1. Note again that n and m not necessarily are integer numbers.

The ratio f_{lamp}/f_{frame} can be implemented as the multiplier factor (k) of the synchronizer 12.

Note that Eq.3 is true only if the pulse frequency f_{pulse} is double the lamp frequency f_{lamp}, and the spoke frequency f_{spoke} is three times the frame rate f_{frame}. For other cases, Eq.2 will have to read differently, and Eq.3 will be altered accordingly. If, for example, the pulse frequency is equal to the lamp frequency, the factor k should be multiplied by a factor two.

To illustrate the effect of such a lamp control, fig 6 shows the scanner position each time a pulse in the light flux occurs. In the illustrated example, the lamp frequency is an average of the 2:nd and 3:rd sub-frequencies, i.e. a multiplier factor, k, equal to 5/8. Again, equal colour bars are assumed. The figure discloses a periodicity of five scanner positions, marked in the figure as T_p. The duration of T_p is five pulses, that is five periods of the light flux 22, or 5/2 periods of the lamp current 20. This in turn equals $(5/2)/(5/8) = 4$ frames.

In fig 7, the five scanner positions during the period T_p are illustrated for each colour separately. It can be seen that within the five scanner positions the individual colours R, G and B can fill the complete scan width h. Through this distribution, the error in light amplitude (caused by the light pulse) is smeared out over the total height h and over the 4 frame time periods.

In order to achieve satisfactory results, the total period of the scanner positions should be sufficiently long, and the distribution over the height h sufficiently even, in order to avoid perceived flickering by the human eye. This can be adjusted with the multiplier factor, given frame rate frequency and allowable lamp frequency.

It is clear that the detailed description above is related to a specific embodiment of the invention, affected by the details of the illustrated scrolling projection system. As has been pointed out above, changes in the system design parameters, such as relationships between frequencies, may require adjustments of the above expressions. Such modifications performed by the skilled man are considered to be covered by the inventive concept defined by the appended claims.

CLAIMS:

1. A scrolling colour projection system, comprising a pulsed lamp and a colour scanner for generating a light beam with a plurality of scrolling colour fields, arranged to illuminate a display device to produce a projection of an image generated by the display device, characterized in that the frequency of the lamp is controlled so as to be related to the frame rate of the display device.

2. A projection system according to claim 1, wherein said lamp frequency is controlled so that the resulting lamp pulse frequency is an average of two consecutive scanner sub-harmonic frequencies causing visible interference patterns in the image.

3. A projection system according to claim 1 or 2, further comprising a frequency multiplier, connected to a synchronisation pulse signal of said display panel, and arranged to multiply said synchronisation pulse signal with a factor, to thereby generate a lamp frequency control signal.

4. A projection system according to claim 3, further comprising a lamp driver, connected to said lamp frequency control signal, and arranged to control the lamp frequency in accordance with said control signal.

5. A method for operating a scrolling colour projection system, comprising a pulsed lamp and a colour scanner for generating a light beam with scrolling colour fields, arranged to illuminate an display device to produce a projection of an image generated by the display device, characterized in controlling the frequency of the lamp so as to be related to the frame rate of the display device.

6. A projection system according to claim 5, wherein said lamp frequency is controlled so that the resulting lamp pulse frequency is an average of two consecutive scanner sub-harmonic frequencies causing visible interference patterns in the image.

7. A method according to claim 5 or 6, wherein the step of controlling the lamp frequency includes:

obtaining a frame synchronization pulse signal,

multiplying said synchronization signal by a factor, to obtain a lamp frequency control signal

controlling the lamp frequency in accordance with said control signal.

8. A method according to claim 7, wherein said factor is defined as:

$k = (3/4)*(1/n + 1/m)$,

where n is the number of a first scanner sub-harmonic frequency, and m is the number of a second scanner sub-harmonic frequency, n and m not necessarily integers.

9. A projection system according to claim 8, wherein n and m represent consecutive sub-harmonic frequencies as listed in table 1.

ABSTRACT:

A scrolling colour projection system, comprising a pulsed lamp (4) and a colour scanner (6, 8a, 8b, 8c, 9) for generating a light beam (5b) with a plurality of scrolling colour fields, arranged to illuminate a display device (1, 3) to produce a projection of an image generated by the display device, wherein the frequency of the lamp is controlled so as to be related to the frame rate of the display device.

By controlling the lamp frequency in relation to the frame rate, a generated interference pattern can be controlled to be distributed over several frame periods and over the entire height of the display. In particular, the pattern can be controlled in such a way that it is not perceivable by the human eye.

Fig. 5

PHNL020914

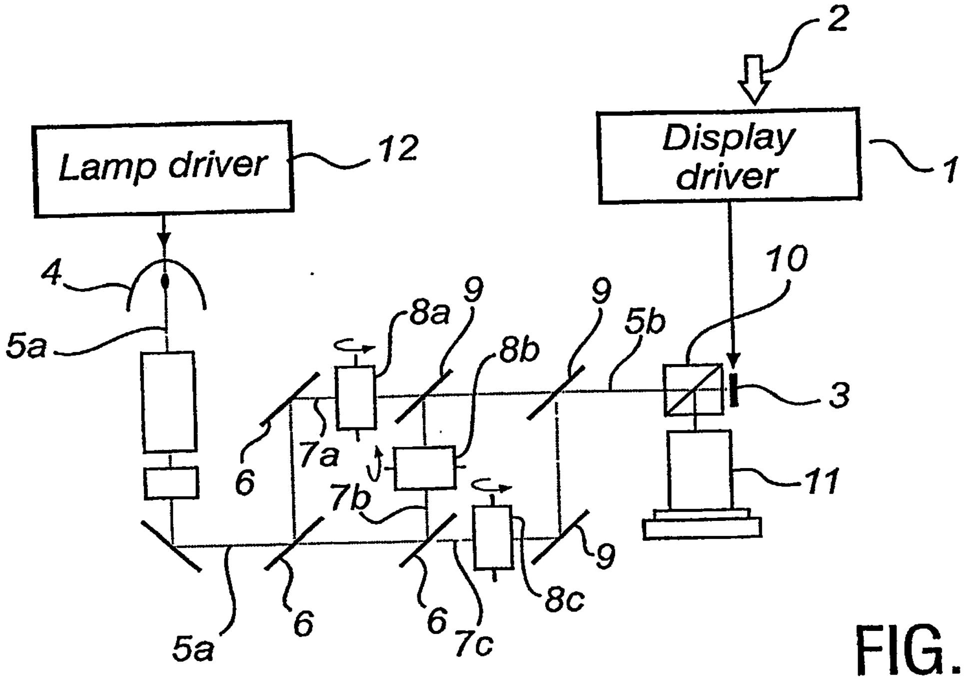


FIG.1

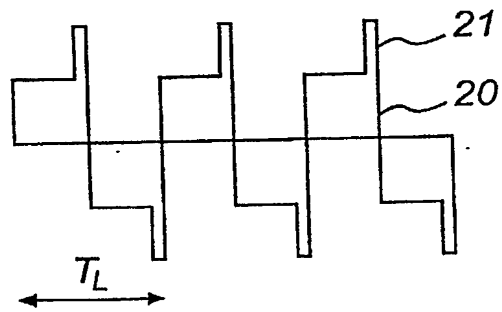


FIG.3

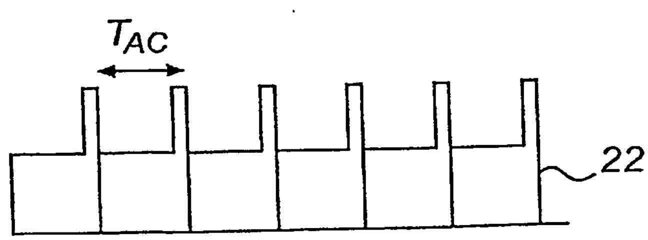


FIG.4

PHNL020914

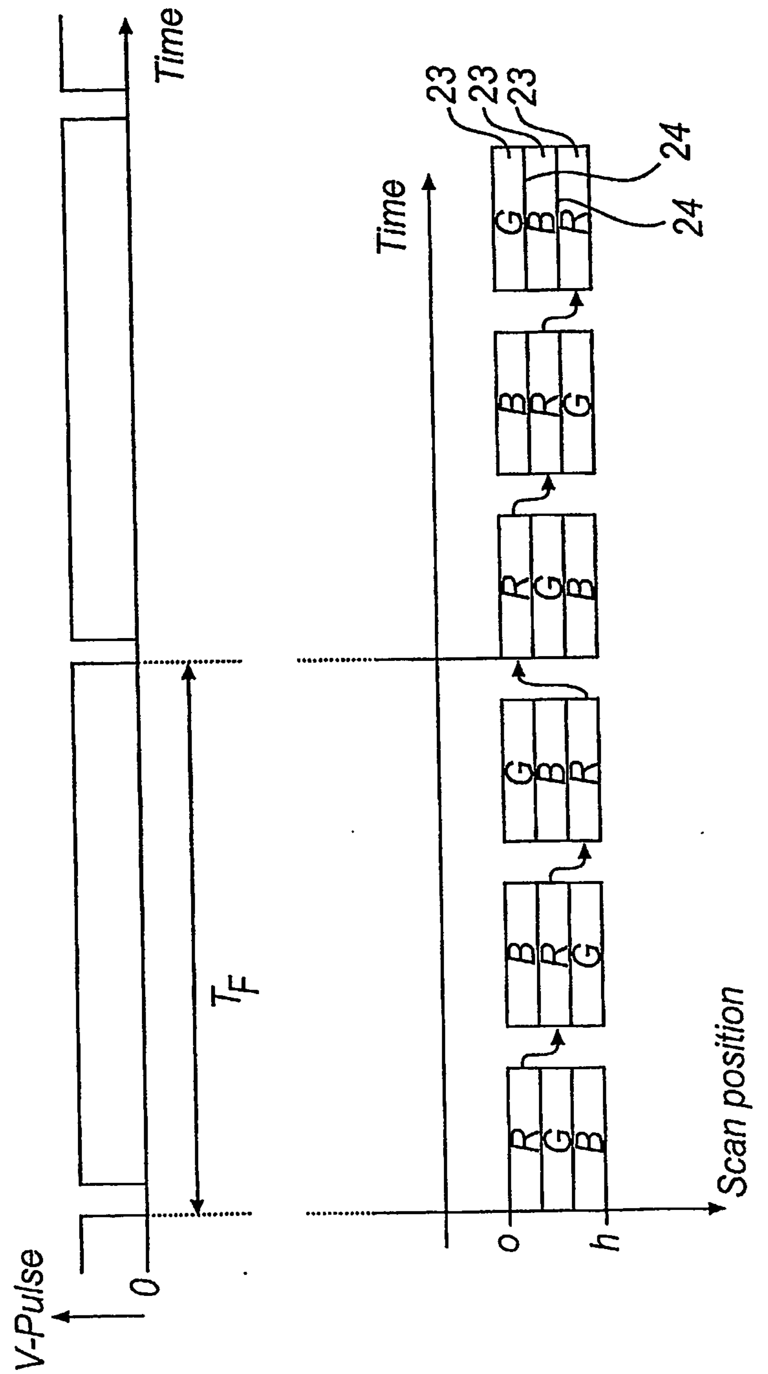


FIG.2

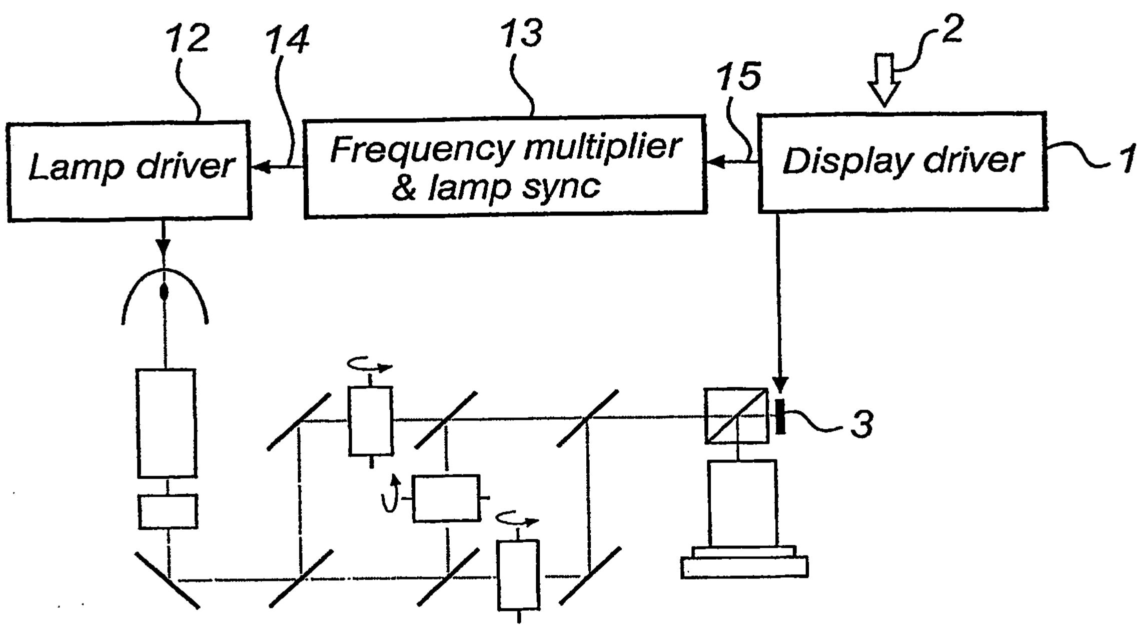
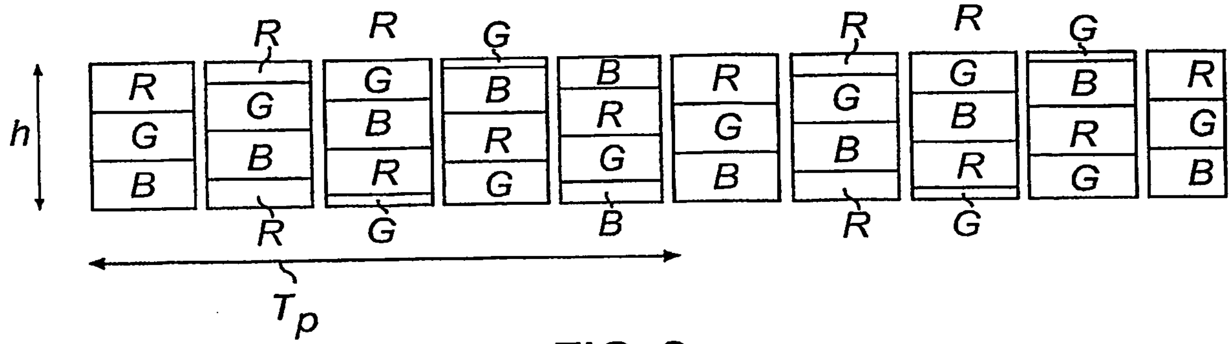

12
14
13
2
15
Lamp driver
Frequency multiplier
& lamp sync
Display driver
1
3

FIG.5


h
R
G
B
R
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G
B
T_p

FIG.6

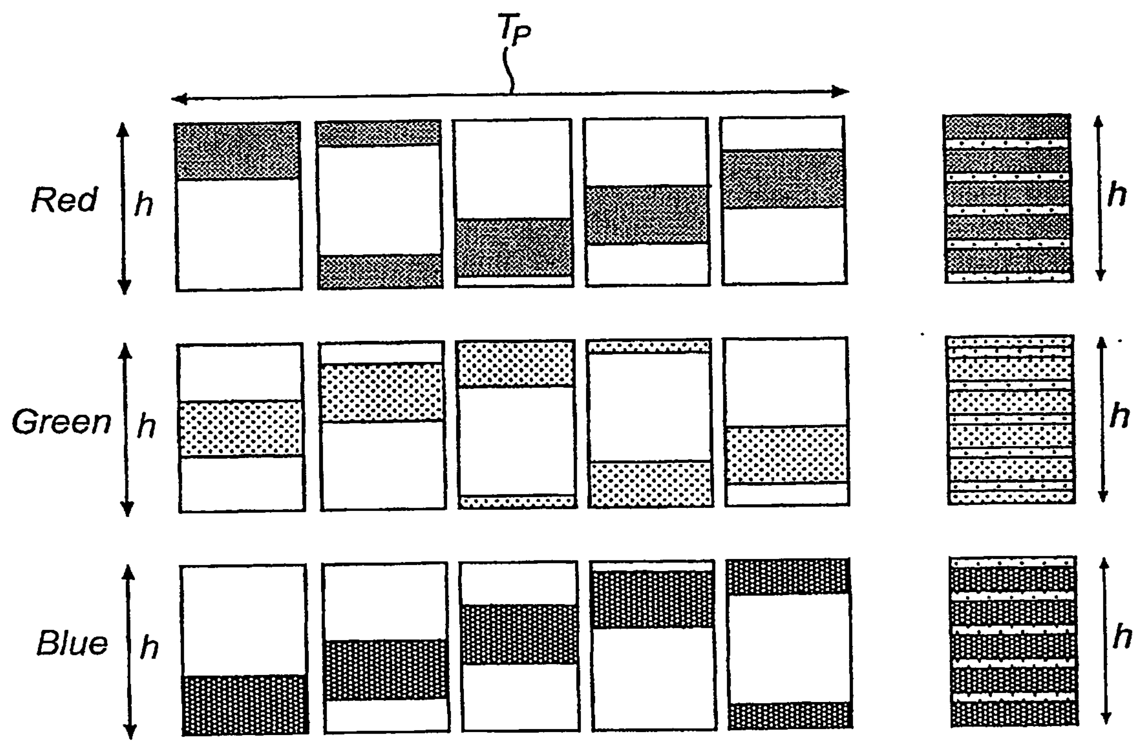
T_P
Red
h
h
Green
h
h
Blue
h
h

FIG.7